

CLAIMS

What is claimed is:

- 1 1. A method comprising:
2 producing a medium access control (MAC) packet that includes a source
3 application-layer timestamp, source data, and a source MAC-layer timestamp,
4 wherein the source MAC-layer timestamp is based on a substantially synchronized
5 clock between a source device and a destination device, and the source MAC-layer
6 timestamp indicates a time when the source data is provided for transmission across
7 a portion of a system that is subject to variable delays.
- 1 2. The method of claim 1, further comprising:
2 receiving an application-layer packet from a source application, wherein the
3 application-layer packet includes the source application-layer timestamp and the
4 source data; and
5 generating the source MAC-layer timestamp in response to receiving the
6 application-layer packet.
- 1 3. The method of claim 2, wherein generating the source MAC-layer
2 timestamp comprises:
3 generating the source MAC-layer timestamp when the application-layer
4 packet enters a medium access control layer of the source device.
- 1 4. The method of claim 1, further comprising:
2 receiving an application-layer packet from a source application, wherein the
3 application-layer packet includes the source application-layer timestamp, the source
4 data, and the source MAC-layer timestamp.

- 1 5. The method of claim 4, further comprising:
2 providing access to the substantially synchronized clock to the source
3 application.
- 1 6. The method of claim 1, further comprising:
2 establishing a fixed transport delay value for the destination device to use to
3 schedule delivery of the source data to a destination application.
- 1 7. The method of claim 6, wherein determining the delay value comprises:
2 performing a negotiation process between the source device and the
3 destination device to determine the fixed transport delay value.
- 1 8. The method of claim 6, wherein determining the delay value comprises:
2 determining a longest observed delay between the source device and the
3 destination device to determine the fixed transport delay value.
- 1 9. The method of claim 1, further comprising:
2 transmitting the MAC packet toward the destination device.
- 1 10. The method of claim 1, wherein the source device is a wireless local area
2 network communications device, and wherein producing the MAC packet is
3 performed by a medium access control device of the source device.
- 1 11. A method comprising:
2 calculating a transport delay experienced by a medium access control
3 (MAC) packet due to a variable delay between a source device and a destination
4 device, wherein the MAC packet includes a source MAC-layer timestamp, a source
5 application-layer timestamp, and source data, and the transport delay is calculated
6 based on the source MAC-layer timestamp and a destination MAC-layer timestamp
7 generated based on a substantially synchronized clock between the source device
8 and the destination device.

1 12. The method of claim 11, further comprising:
2 a destination application using the transport delay and the source
3 application-layer timestamp to perform an application clock recovery process.

1 13. The method of claim 11, further comprising:
2 generating a destination MAC-layer timestamp, which indicates an
3 approximate time when the source data is ready to be provided to a destination
4 application, wherein the destination MAC-layer timestamp is based on the
5 substantially synchronized clock, and the destination MAC-layer timestamp and the
6 source MAC-layer timestamp are used in calculating the transport delay.

1 14. The method of claim 11, further comprising:
2 establishing a fixed transport delay value for the destination device to use to
3 schedule delivery of the source data to a destination application; and
4 delaying delivery of the MAC packet to the destination application by a
5 retiming delay, which is approximately equal to the fixed transport delay value
6 minus the transport delay.

1 15. The method of claim 14, further comprising:
2 discarding the source data if the transport delay exceeds the fixed transport
3 delay value.

1 16. The method of claim 14, wherein establishing the fixed transport delay value
2 comprises:
3 performing a negotiation process between the source device and the
4 destination device to determine the fixed transport delay value.

1 17. The method of claim 14, wherein establishing the fixed transport delay value
2 comprises:
3 determining a longest observed delay between the source device and the
4 destination device to determine the fixed transport delay value.

1 18. The method of claim 11, further comprising:
2 providing access to the substantially synchronized clock to the destination
3 application, to enable the destination application to calculate the destination
4 transport delay and to perform a clock recovery process.

1 19. The method of claim 11, wherein the destination device is a wireless local
2 area network communications device, and wherein calculating the transport delay is
3 performed by a medium access control element of the destination device.

1 20. A method comprising:
2 producing, by a source device, a medium access control (MAC) packet that
3 includes a source application-layer timestamp, source data, and a source MAC-layer
4 timestamp, wherein the source MAC-layer timestamp is based on a substantially
5 synchronized clock between the source device and a destination device, and the
6 source MAC-layer timestamp indicates a time when the source data is provided for
7 transmission across a portion of a system that is subject to variable delays;
8 transmitting the MAC packet from the source device to the destination
9 device; and
10 calculating, by the destination device, a transport delay applied to the MAC
11 packet based on the source MAC-layer timestamp and a destination MAC-layer
12 timestamp generated based on the substantially synchronized clock.

1 21. The method of claim 20, further comprising:
2 establishing a fixed transport delay value for the destination device to use to
3 schedule delivery of the source data to a destination application; and
4 the destination device delaying delivery of the source data to the destination
5 application by a retiming delay that is approximately equal to the fixed transport
6 delay value minus the transport delay.

1 22. The method of claim 20, further comprising:
2 generating a destination MAC-layer timestamp, which indicates an
3 approximate time when the source data is ready to be provided to a destination
4 application, wherein the destination MAC-layer timestamp is based on the
5 substantially synchronized clock, and the destination MAC-layer timestamp and the
6 source MAC-layer timestamp are used in calculating the transport delay.

1 23. An apparatus comprising:
2 a medium access control (MAC) packet production element, which produces
3 a MAC packet that includes a source application-layer timestamp, source data, and a
4 source MAC-layer timestamp, wherein the source MAC-layer timestamp is based
5 on a substantially synchronized clock between a source device and a destination
6 device, and the source MAC-layer timestamp indicates a time when the source data
7 is provided for transmission across a portion of a system that is subject to variable
8 delays; and
9 a clock that is capable of being used as the substantially synchronized clock.

1 24. The apparatus of claim 23, further comprising:
2 a source application interface, which receives an application-layer packet
3 from a source application, wherein the application-layer packet includes the source
4 application-layer timestamp and the source data; and
5 a timestamp generation element, which generates the source MAC-layer
6 timestamp in response to receiving the application-layer packet.

1 25. The apparatus of claim 23, further comprising:
2 a source application interface, which receives an application-layer packet
3 from a source application, wherein the application-layer packet includes the source
4 application-layer timestamp, the source data, and the source MAC-layer timestamp.

1 26. The apparatus of claim 23, further comprising:
2 a clock interface, which enables the substantially synchronized clock to be
3 provided to a source application.

1 27. The apparatus of claim 23, wherein the apparatus forms a portion of a
2 wireless local area network device, and the apparatus further comprises:
3 an antenna for transmitting the MAC packet over a device-to-device
4 communication link.

1 28. An apparatus comprising:
2 a transport delay calculation element, which calculates a transport delay
3 applied to a medium access control (MAC) packet, wherein the MAC packet
4 includes a source MAC-layer timestamp, a source application-layer timestamp, and
5 source data, and the transport delay is calculated based on the source MAC-layer
6 timestamp and a substantially synchronized clock between the source device and the
7 destination device; and
8 a clock that is capable of being used as the substantially synchronized clock.

1 29. The apparatus of claim 28, further comprising:
2 a destination MAC-layer timestamp generation element, which generates a
3 destination MAC-layer timestamp that indicates an approximate time when the
4 source data will be provided to a destination application, wherein the destination
5 MAC-layer timestamp is based on the substantially synchronized clock, and the
6 destination MAC-layer timestamp and the MAC-layer timestamp are used in
7 calculating the transport delay.

1 30. The apparatus of claim 28, further comprising:
2 a fixed transport delay element, which delays delivery of the source data to a
3 destination application by a retiming delay that is approximately equal to a fixed
4 transport delay value minus the transport delay.

1 31. The apparatus of claim 28, further comprising:
2 a clock interface, which enables the substantially synchronized clock to be
3 provided to a destination application.

1 32. The apparatus of claim 28, wherein the apparatus forms a portion of a
2 wireless local area network device, and the apparatus further comprises:
3 an antenna for receiving the MAC packet over an air interface.

1 33. A computer-readable medium having program instructions stored thereon to
2 perform a method, which when executed within an electronic device, result in:
3 producing a medium access control (MAC) packet that includes a source
4 application-layer timestamp, source data, and a source MAC-layer timestamp,
5 wherein the source MAC-layer timestamp is based on a substantially synchronized
6 clock between a source device and a destination device, and the source MAC-layer
7 timestamp indicates a time when the source data is provided for transmission across
8 a portion of a system that is subject to variable delays.

1 34. The computer-readable medium of claim 33 wherein execution of the
2 method further results in:
3 receiving an application-layer packet from a source application, wherein the
4 application-layer packet includes the source application-layer timestamp and the
5 source data; and
6 generating the source MAC-layer timestamp in response to receiving the
7 application-layer packet.

1 35. The computer-readable medium of claim 33, wherein execution of the
2 method further results in:
3 receiving an application-layer packet from a source application, wherein the
4 application-layer packet includes the source application-layer timestamp, the source
5 data, and the source MAC-layer timestamp.

1 36. The computer-readable medium of claim 33, wherein execution of the
2 method further results in:
3 providing access to the substantially synchronized clock to the source
4 application.

1 37. A computer-readable medium having program instructions stored thereon to
2 perform a method, which when executed within an electronic device, result in:
3 calculating a transport delay experienced by a medium access control
4 (MAC) packet due to a variable delay between a source device and a destination
5 device, wherein the MAC packet includes a source MAC-layer timestamp, a source
6 application-layer timestamp, and source data, and the transport delay is calculated
7 based on the source MAC-layer timestamp and a destination MAC-layer timestamp
8 generated based on a substantially synchronized clock between the source device
9 and the destination device.

1 38. The computer-readable medium of claim 37, wherein execution of the
2 method further results in:
3 generating a destination MAC-layer timestamp, which indicates an
4 approximate time when the source data is ready to be provided to a destination
5 application, wherein the destination MAC-layer timestamp is based on the
6 substantially synchronized clock, and the destination MAC-layer timestamp and the
7 source MAC-layer timestamp are used in calculating the transport delay.

1 39. The computer-readable medium of claim 37, wherein execution of the
2 method further results in:
3 establishing a fixed transport delay value for the destination device to use to
4 schedule delivery of the source data to a destination application; and
5 delaying delivery of the MAC packet to the destination application by a
6 retiming delay, which is approximately equal to the fixed transport delay value
7 minus the transport delay.

1 40. The computer-readable medium of claim 37, wherein execution of the
2 method further results in:
3 providing access to the substantially synchronized clock to the destination
4 application, to enable the destination application to calculate the transport delay and
5 to perform a clock recovery process.